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Revision 1
April 2003

Project No. 23366

U.S. Department of Energy
Idaho Operations Office

Field Sampling Plan for the Waste Area Group 5, Remedial Action, Phase II

INEEL
Home of Science and Engineering Solutions
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Prepared for the
U.S. Department of Energy
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ABSTRACT

This field sampling plan outlines the collection and analysis of samples in support of Phase II of the Waste Area Group 5, Operable Unit 5-12, remedial action, which is being performed as defined in the *Final Record of Decision for Power Burst Facility and Auxiliary Reactor Area.*

Phase II addresses the remedial actions at three contaminated soil sites, including the Auxiliary Reactor Area (ARA)-O1 Chemical Evaporation Pond, the ARA-12 Radioactive Waste Leach Pond, and the ARA-23 Radiologically Contaminated Soils. Contaminated soil will be removed during Phase II activities from the three Comprehensive Environmental Response, Comprehension and Liability Act (CERCLA) sites and dispositioned at the Idaho National Engineering and Environmental Laboratory (INEEL) CERCLA Disposal Facility, or other approved disposal facility on the INEEL. Field screening surveys will be performed at the sites after removal of the first layer of contaminated soil to quantify the residual concentrations of the contaminants of concern. If areas are identified as exceeding the remedial action goals, additional selective excavation will occur to remove the contaminated soil. The area will then be resurveyed and confirmation samples collected to demonstrate that contamination has been removed to levels below the remedial action goals. Contaminated soils will be removed and remaining soils screened through an iterative process until field screening results show that contaminant concentrations are at or below the remedial action goals for the respective site. Confirmation sampling and in situ measurements will be performed to demonstrate that the remedial action goals are met in accordance with the *Final Record of Decision for Power Burst Facility and Auxiliary Reactor Area.*

CONTENTS

FIGURES

TABLES

ACRONYMS

ARA	Auxiliary Reactor Area
ARAR	applicable or relevant and appropriate requirement
BBWI	Bechtel BWXT Idaho, LLC
CC	Construction Coordinator
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
COC	contaminant of concern
CSA	CERCLA storage area
CWSU	CERCLA waste storage unit
D&D&D	deactivation, decontamination and dismantlement
DOE-ID	Department of Energy Idaho Operations Office
DOT	Department of Transportation
DQO	Data Quality Objective
DS	decision statement
EPA	Environmental Protection Agency
ER	environmental restoration
ERDF	Environmental Restoration Disposal Facility
ERPC	Environmental Restoration Program Coordination
ES&H	environment, safety, and health
FSP	field sampling plan
FTL	field team leader
GPRS	global positioning radiometric scanner
HASP	health and safety plan
HPGe	high-purity germanium

ICDF	INEEL CERCLA Disposal Facility
INEEL	Idaho National Engineering and Environmental Laboratory
MCP	management control procedure
OU	operable unit
PBF	Power Burst Facility
PPE	personal protective equipment
PQL	practical quantitation limit
PSQ	principle study question
QA	quality assurance
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
RADCON	radiological control
RCRA	Resource Conservation Recovery Act
RCT	Radiological Control Technician
ROD	record of decision
RRWAC	reusable property, recyclable materials, and waste acceptance criteria
RWMC	Radioactive Waste Management Complex
S&H/QA	Safety & Health/Quality Assurance
SAM	Sample Analytical Management
SAP	sampling and analysis plan
SL-1	Stationary Low-Power Reactor No. 1
SPERT	Special Power Excursion Reactor Test
TPR	Technical procedure
UCL	Upper confidence limit
WAC	waste acceptance criteria
WAG	waste area group

WGS	Waste Generator Services
WROC	Waste Reduction Operations Complex
XRF	x-ray fluorescence

Field Sampling Plan for the Waste Area Group 5, Remedial Action, Phase II

1. OVERVIEW

The sampling and analysis plan (SAP) for the Idaho National Engineering and Environmental Laboratory (INEEL) Waste Area Group (WAG) 5 Remedial Action is comprised of two parts:

- Field sampling plan (FSP)
- Quality assurance project plan (QAPjP).

These plans have been prepared in accordance with the *National Oil and Hazardous Substances Contingency Plan,* (U.S. Environmental Protection Agency [EPA] 1990), guidance from the EPA on the preparation of SAPs, and Management Control Procedure (MCP)-9439, "Preparation for Environmental Sampling Activities at the INEEL." The FSP describes the field sampling activities that will be performed, while the QAPjP details the processes and programs that will be used to ensure that the data generated are suitable for their intended uses. The governing QAPjP for this sampling effort will be the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10 and Inactive Sites* (U.S. Department of Energy Idaho Operations Office [DOE-ID] 2002a). This document is incorporated herein by reference. Work control processes will follow formal practices as per communicated agreement between the appropriate site area directors and the environmental restoration (ER) project manager.

1.1 Field Sampling Plan

The remedial action for WAG 5 is divided into two phases. Phase I is specific to tanks and inactive septic system components located at the Auxiliary Reactor Area (ARA). Phase II is concerned with the remediation of contaminated soils located at ARA. The purpose of this FSP is to guide the collection and analysis of samples required to confirm that the remedial action objectives for Phase II have been met by the remedial action. The project is being conducted in accordance with the requirements set forth in the *Final Record of Decision for Power Burst Facility and Auxiliary Reactor Area* (DOE-ID 2000a).

The selected remedy for WAG 5 comprises three remedial actions to mitigate the risks associated with seven specific sites. The Phase II remedial action addresses a collection of five individual sites (ARA-01, ARA-12, ARA-23, ARA-25, and Power Burst Facility [PBF] -16) where contaminated soil is the only source medium.

The Phase II sites covered under this FSP that require remedial action under the operable unit (OU) 5-12 Record of Decision (ROD) (DOE-ID 2000a) include the ARA-I Chemical Evaporation Pond (ARA-01), the ARA-III Radioactive Waste Leach Pond (ARA-12), and the ARA-I and ARA-II Radiologically Contaminated Soils (ARA-23).

The remedial action for ARA-25 occurred as part of the Phase I activities. The overlap of the ARA-25 and ARA-16 areas necessitated the removal of the concrete and contaminated soils associated with the ARA-25 site. The remedial activities conducted at the ARA-25 site are detailed in the OU 5-12 Phase I remedial action report (DOE-ID 2002b).

Surface and subsurface sampling of the PBF-16 leach pond was performed in June of 2000 to determine the extent of mercury contamination in excess of the 0.5 mg/kg remedial action goal

(INEEL 2000a). Mercury was identified as posing an unacceptable ecological risk in the OU 5-12 comprehensive remedial investigation/facility study (RI/FS) baseline risk assessment (DOE-ID 1999). The analytical data from the soil sample analyses show that the average mercury concentration in the surficial and subsurface soils at the PBF-16 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site is less than the 0.5 mg/kg. The maximum concentration detected in surface soils was 0.12 mg/kg. The maximum concentration detected in subsurface soils was 0.23 mg/kg at a depth interval of 0.15 to 0.45 m (0.5 to 1.5 ft). There was no mercury detected below this depth (Kirkpatrick 2000). As a result, there will be no further sampling at the PBF-16 site.

1.1.1 Field Sampling Objectives

The purpose of this field sampling plan is to guide the collection and analysis of field screening data and soil samples at three CERCLA sites in OU 5-12 at the INEEL, including the ARA-I Chemical Evaporation Pond (ARA-01), the ARA-III Radioactive Waste Leach Pond (ARA-12), and the ARA-I and ARA-II Radiologically Contaminated Soils (ARA-23). The primary objective of this field sampling effort is to confirm that contaminant concentrations at the three CERCLA sites are below the remedial action goals defined in the record of decision (ROD).

As part of the Phase II remedial action, hot spots inside the Stationary Low-Power Reactor No. 1 (SL-1) burial ground will also be remediated in conjunction with the ARA-23 site remediation. At the conclusion of the remedial action, confirmation samples will be collected at all remediated sites to demonstrate compliance with the remedial action objectives as stated in the ROD (DOE-ID 2000a).

1.1.2 Other Documentation

The health and safety plan (HASP) prepared for this project, *Health and Safety Plan for Operable Unit 5-12 Remedial Design/Remedial Action Projects* (INEEL 2003), covers the activities associated with the remediation of the remaining three soil sites as well as activities associated with WAG 5 groundwater monitoring. The HASP includes an auditable safety analysis in accordance with the *Hazard Classification for Remedial Activities at Eleven OU 5-12 Sites: ARA-01, ARA -02, ARA -0 7, ARA -08, ARA-12, ARA-13, ARA-16, ARA -21, ARA -23, ARA -25, and PBF-16* (INEEL 2000b).

The *Interface Agreement Between the Environmental Restoration Program, Waste Area Groups 4, 5, 10, and Deactivation, Decontamination, and Dismantlement (D&D&D) and the Central Facilities Area* (INEEL 2002) includes activities carried out at ARA, which come under the purview of the Central Facilities Area (CFA) Site Area Director.

1.2 Project Organization and Responsibility

The organizational structure for this work reflects the resources and expertise required to plan and perform the work, while minimizing risks to worker health and safety. The HASP (INEEL 2003) provides the job titles of the individuals who will be filling the key roles, and lines of responsibility and communication.

2. SITE BACKGROUND

2.1 Site Description

Located 51 km (32 mi.) west of Idaho Falls, Idaho, the INEEL is a government-owned, contractor-operated facility managed by the DOE-ID (Figure 2-1). Occupying 2,305 km^2 (890 mi^2) of the northeastern portion of the Eastern Snake River Plain, the INEEL encompasses portions of five Idaho counties: Butte, Jefferson, Bonneville, Clark, and Bingham.

WAG 5 is in the south-central portion of the INEEL and comprises the ARA and the PBF (Figure 2-2). The ARA consists of four separate operational areas designated as ARA-I, ARA-II, ARA-III, and ARA-IV. Once known as the Special Power Excursion Reactor Test (SPERT) facilities, PBF consists of five separate operational areas: the PBF Control Area, the PBF Reactor Area (SPERT-I), the Waste Engineering Development Facility (SPERT-II), the Waste Experimental Reduction Facility (SPERT-III), and the Mixed Waste Storage Facility (SPERT-IV). Collectively, the Waste Experimental Reduction Facility, the Waste Engineering Development Facility, and the Mixed Waste Storage Facility are known as the Waste Reduction Operations Complex (WROC). The following sections describe the ARA-01, ARA-12, and ARA-23 contaminated soil sites that will require sampling under this FSP.

2.1.1 ARA-01: ARA-I Chemical Evaporation Pond

The ARA-01 site is a shallow, unlined surface impoundment, roughly 30 × 90 m (100 × 300 ft) in size, that was used to dispose of laboratory wastewater from the ARA-I Shop and Maintenance Building (ARA-627). Located southeast of ARA-I (see Figure 2-3), the pond was constructed in 1970 by excavating soil to create a shallow topographic depression. Basalt outcrops are present within and immediately adjacent to the pond. The subsurface immediately beneath the pond consists of fracture and rubble zones.

2.1.2 ARA-12: ARA-III Radioactive Waste Leach Pond

The ARA-12 site is an unlined surface impoundment constructed in a natural depression west of ARA-III across Wilson Boulevard (see Figure 2-4). The ARA-III facility was an active reactor research facility from about 1959 to 1965. The pond was constructed to receive low-level liquid waste from reactor research operations. Liquid waste was stored temporarily in tanks, then transferred to the leach pond via an underground pipe. A second, separate line to the leach field originated in an uncontaminated water storage tank (ARA-709). A third source of effluent was facility runoff via a culvert. The depressional area within ARA-12 measures approximately 50 × 115 m (164 × 377 ft), although the portion of the pond historically exposed to wastewater is thought to be much smaller in area. In 1991, the culvert was plugged in preparation for D&D&D operations at ARA-III. The tanks and waste lines to the leach pond were removed in 1993 during the D&D&D of ARA-III.

2.1.3 ARA-23: Radiologically Contaminated Surface Soils and Subsurface Structures Associated With ARA-I and ARA-II

The ARA-23 site is a large, roughly oval-shaped windblown contamination site encompassing the SL-1 Burial Ground and the remnants of the ARA-I and ARA-II facilities (see Figure 2-5). The long axis of the site is consistent with the generally southwest to northeast winds common on the INEEL. Soils were radiologically contaminated by the 1961 SL-1 reactor accident and subsequent cleanup. Minor amounts of contamination may have been added by other ARA operations. Over time, winds dispersed the contamination over an area roughly 100 ha (240 acres) in size.

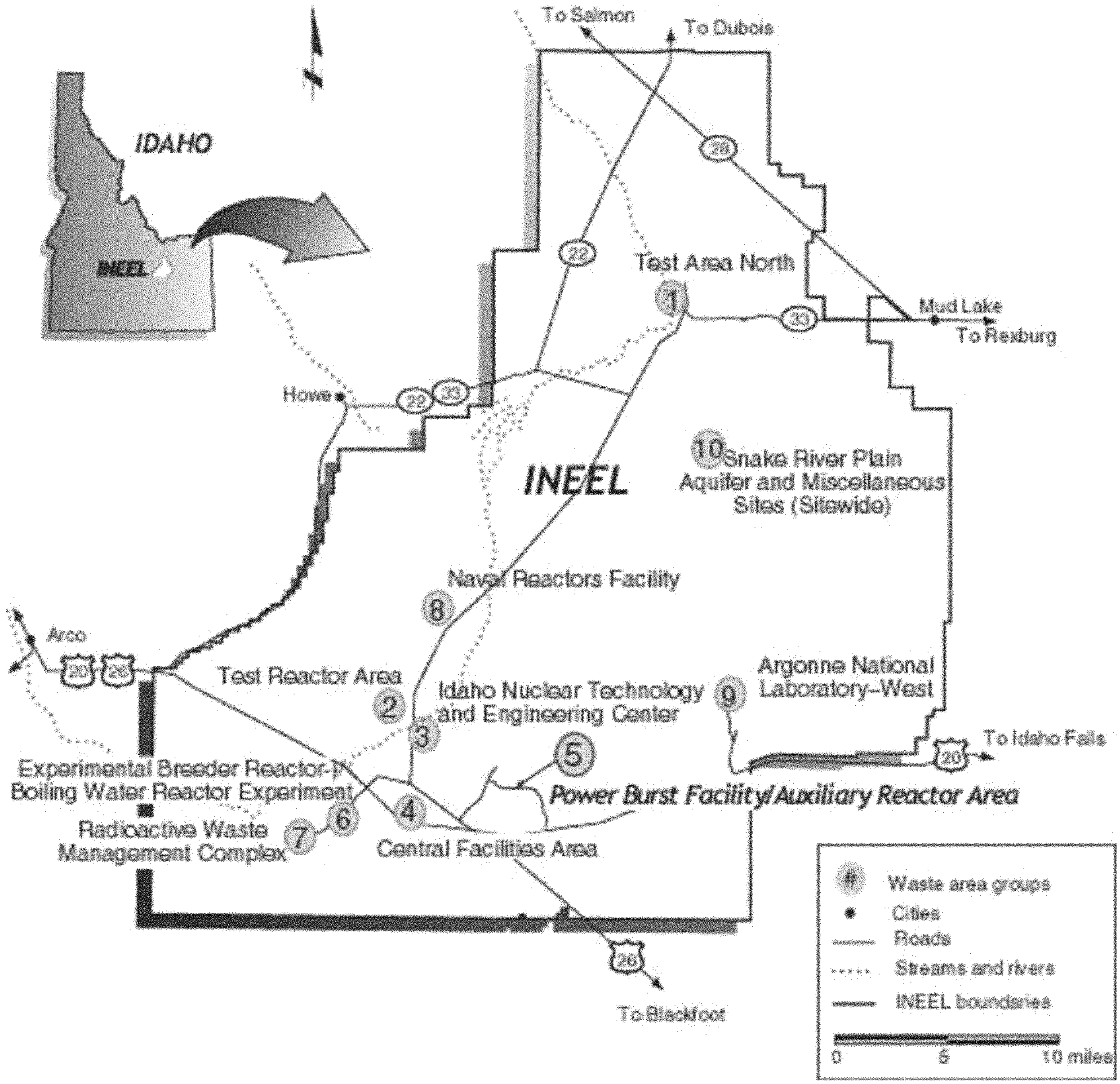

Figure 2-1. Location of Waste Area Group 5 at the Idaho National Engineering and Environmental Laboratory.

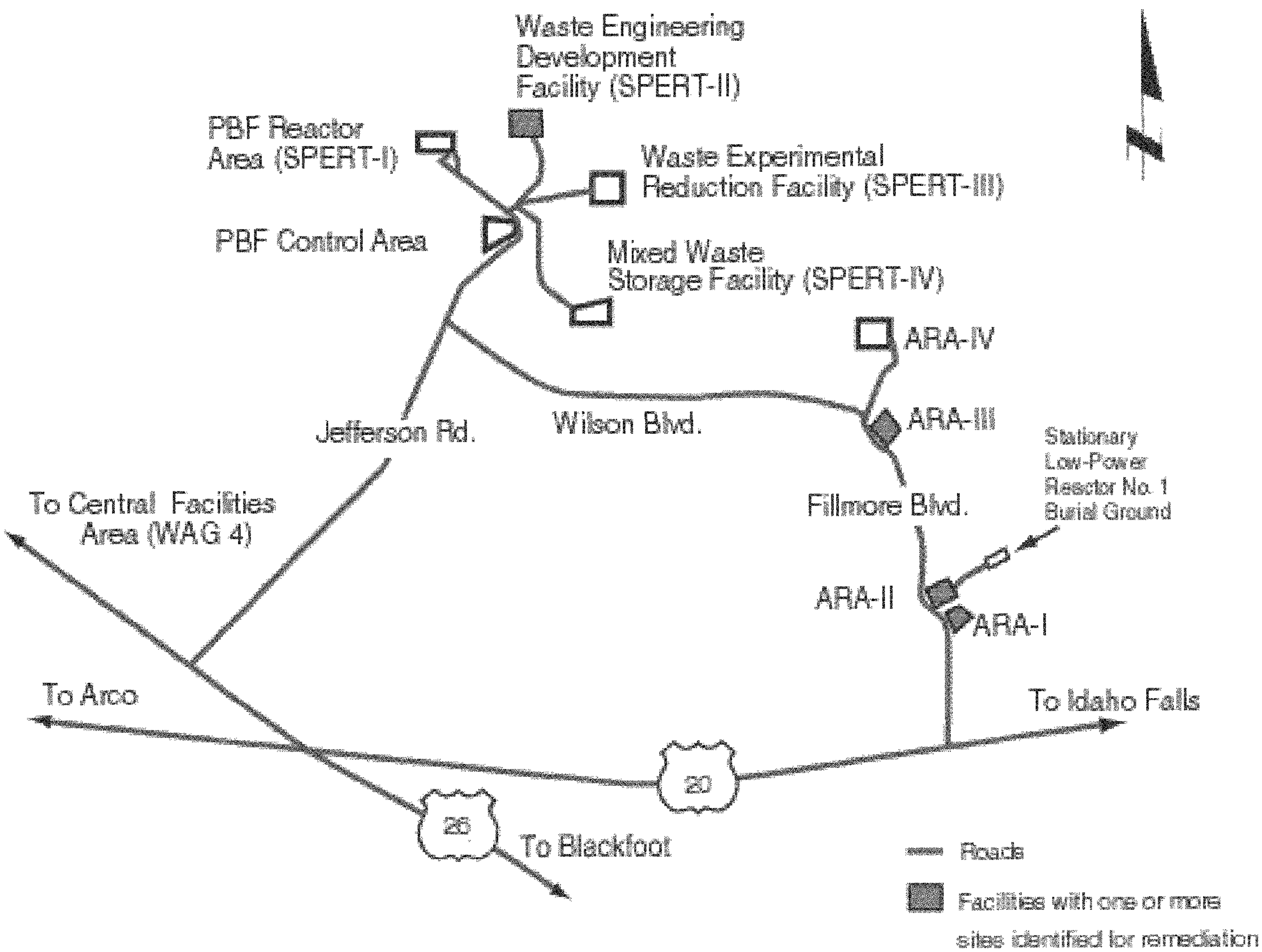

Figure 2-2. Detail of Auxiliary Reactor Area facilities within Waste Area Group 5.

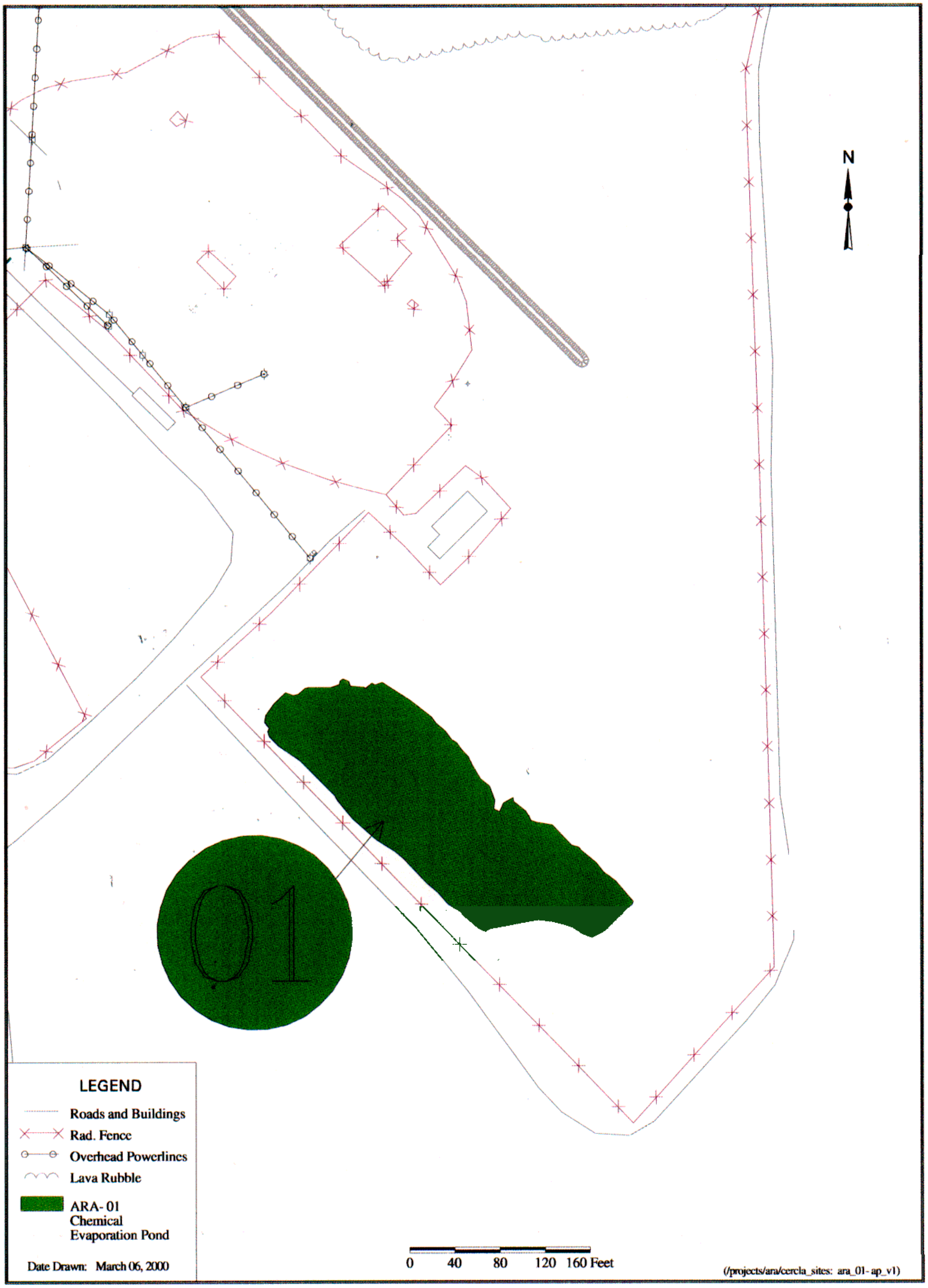

Figure 2-3. Areal view of ARA-01 site showing estimated extent of contamination.

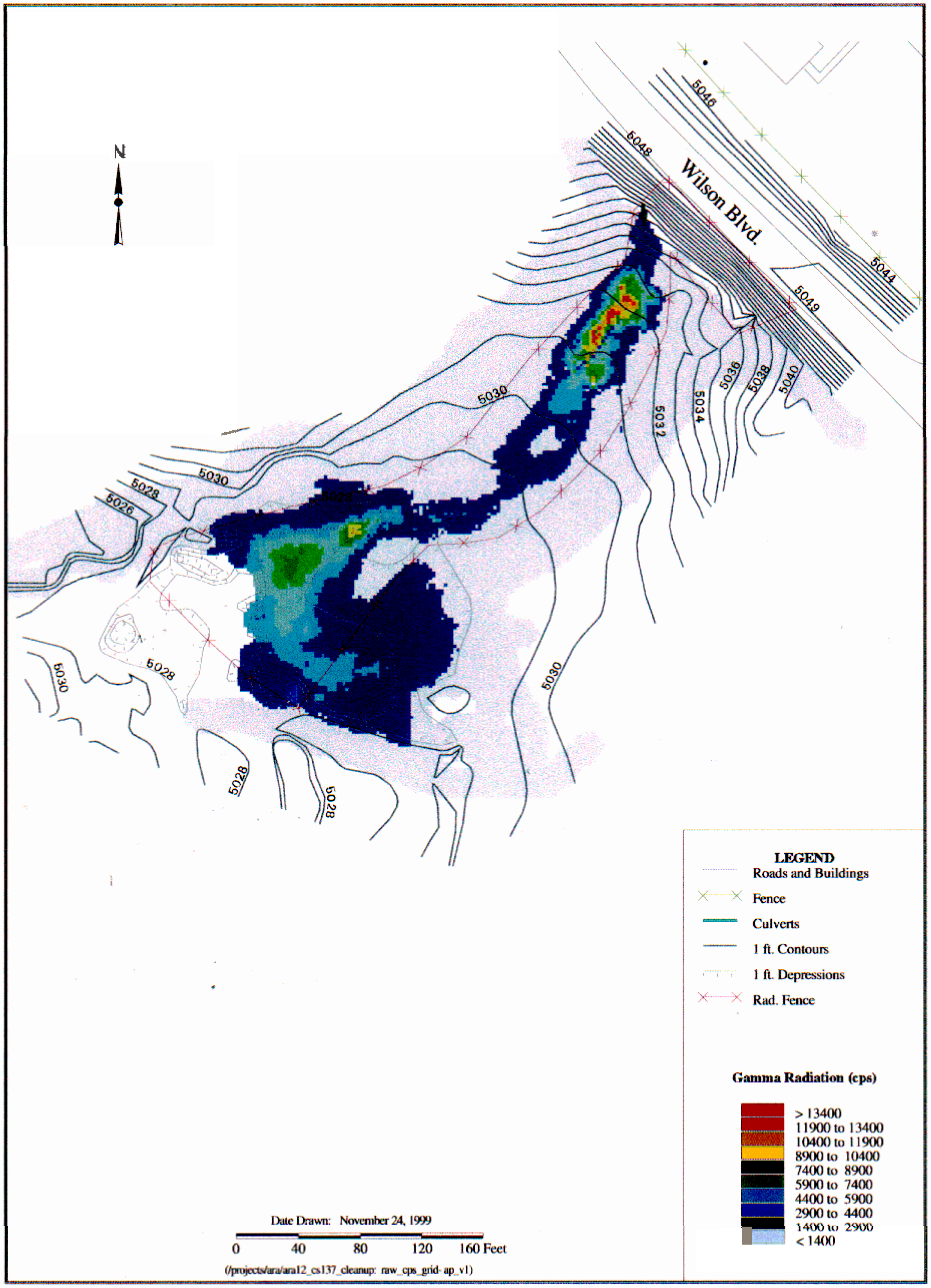

Figure 2-4. Location of ARA-12 with gamma survey showing radiological hot spots.

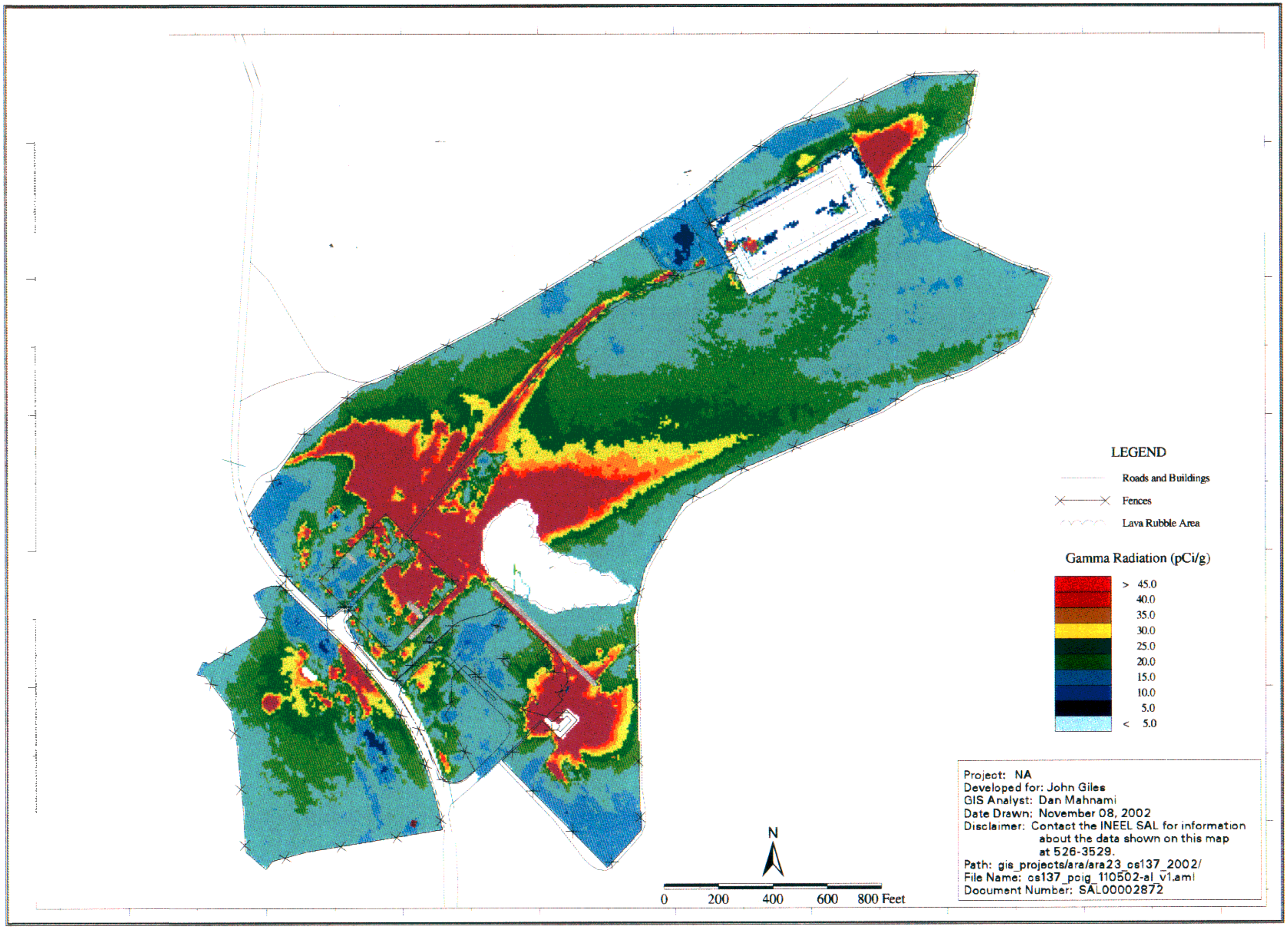

Figure 2-5. Areal view of ARA-23 site with detailed gamma survey showing extent of Cs-137 contamination.

2.2 Nature and Extent of Contamination

Remedial action is required for three contaminated soil sites: the ARA-I Chemical Evaporation Pond (ARA-01), the ARA-III Radioactive Waste Leach Pond (ARA-12), and the ARA-I and ARA-II Radiologically Contaminated Soils (ARA-23). The following sections provide a brief description of the three contaminated soil sites that require remediation. Detailed information about the individual sites can be found in the WAG 5 Comprehensive Remedial Investigation/Feasibility Study report (Holdren et al. 1999).

2.2.1 ARA-01: Chemical Evaporation Pond

From 1970 to 1988, the pond received process discharges that contained small quantities of radioactive substances, acids, bases, and volatile organic compounds. Since 1988, the pond has been dry except during spring runoff and heavy precipitation. Based upon data collected during a 1982 sampling event, results of the ARA-01 baseline risk assessment (Stanisich et al. 1992), and additional sampling conducted as part of the *Final Work Plan for Waste Area Group 5, Operable Unit 5-12 Comprehensive Remedial Investigation/Feasibility Study* (DOE-ID 1997), a risk assessment was performed. The human health risk assessment identified arsenic as a contaminant of concern (COC) based on human health risk estimates. In addition, the ecological risk assessment identified selenium and thallium as COCs based on hazard quotients for ecological receptors. Figure 2-3 also shows the estimated boundary of contamination at ARA-01.

2.2.2 ARA-12: ARA-III Radioactive Waste Leach Pond

The Track 2 evaluation initiated in 1993 and completed in 1994 (Pickett et al. 1994) determined that a total risk of 2E-03 was estimated for the 100-year future residential nonintrusion scenario, primarily due to direct exposure to Ag-108m, Cs-137, and U-238. As part of the Waste Area Group 5, Operable Unit 5-12 Comprehensive Remedial Investigation/Feasibility Study, (Holdren et al. 1999), a survey of the ARA-12 surface soil was conducted with the global positioning radiometric scanner (GPRS). Initially, the elevated gamma levels were attributed to Cs-137, but subsequent soil sample analyses showed Ag-108m to be the source (Giles 1999). The human health risk assessment identified Ag-108m as a COC for ARA-12 based on human health risk estimates. The ecological risk assessment determined that copper, mercury, and selenium were COCs based on hazard quotients for ecological receptors. Figure 2-6 provides the results of the in situ gamma survey of ARA-12 and estimated Ag-108m concentrations in the top 2.54 cm (1 in.) of soil. Four soil samples were collected and analyzed for toxicity characteristic leaching procedure (TCLP) and total metals concentrations in 1999 to demonstrate that the ARA-12 soils were not characteristic for metals. TCLP metals analysis shows that all analytes are either non-detect, or below the maximum concentration for the toxicity characteristic. Additionally, totals data for metals are all within acceptable ranges for INEEL soils. Specifically for silver, three of the TCLP samples were non-detect, and the fourth showed a concentration of 295 µg/L. Silver was non-detect in all four total metals samples (Kirchner 1999).

2.2.3 ARA-23: Radiologically Contaminated Surface Soils and Subsurface Structures Associated With ARA-I and ARA-II

A Track 1 investigation was initiated for ARA-23 in 1993, but was not finalized because the site was reassigned to OU 10-06 for evaluation. The OU 10-06 evaluation, which excluded the areas within the ARA-I and ARA-II facility fences, was only partially completed before ARA-23 was reassigned to WAG 5 for final disposition. The data gaps identified in the WAG 5 Work Plan (DOE-ID 1997) comprised the horizontal and vertical extent of Cs-137 in the windblown soil area and the presence of other radionuclides such as cobalt (Co) -60, europium (Eu) -152, Eu-154, strontium (Sr) -90, and uranium isotopes. Based on the sampling and analytical results combined with the surface gamma-radiation survey

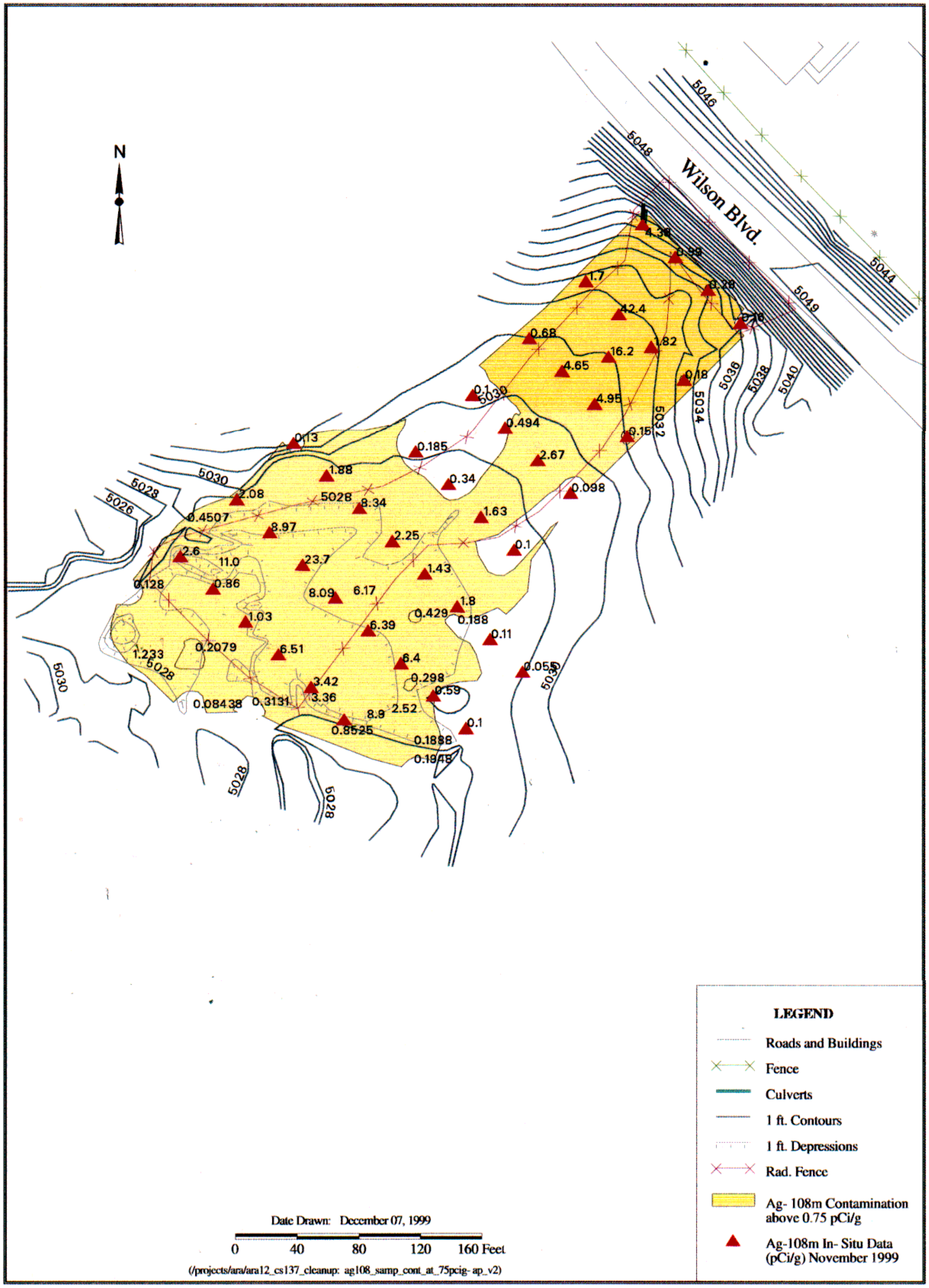

Figure 2-6. Results of in situ gamma spectroscopy measurements at the ARA-12 site showing the 0.75 pCi/g isopleth for Ag-108m.

conducted using the GPRS, a risk assessment was performed. Cesium-137 was identified as the primary contributor to the estimated total risk for all pathways. The ARA-23 site was screened for evaluation in the ecological risk assessment because the only contaminants above background levels are radionuclides. Figure 2-5 also provides the results of the in situ gamma survey of ARA-23 and estimated Cs-l37 concentrations in the top 2.54 cm (1 in.) of soil.

2.3 Project Description

Based on consideration of the requirements of CERCLA, the detailed analysis of alternatives, and public comments, the Agencies have chosen removal and disposal as the selected remedy for the contaminated soil sites. Performance standards were implemented as design criteria for each of the contaminated soil sites to ensure that the selected remedy is protective of human health and the environment. Five-year reviews will be used to ensure that the selected remedies remain protective and appropriate.

2.3.1 Contaminated Soil Sites

The selected remedy for the WAG 5 contaminated soil sites, as identified in the ROD, is removal and on-Site disposal of the contaminated soil at the INEEL. This remedy was selected based on the results of the comparative analysis of alternatives. Removal and disposal is the least costly alternative that meets the threshold criteria (i.e., the remedy provides overall protection of human health and the environment and satisfies applicable or relevant and appropriate requirements [ARARs]), removal and disposal is easily implemented because the required equipment already exists at the INEEL and it has a high long-term effectiveness because contamination will be permanently removed from the sites. The estimated time required to complete remediation is 18 to 24 months. The following activities will be conducted to complete remediation of the contaminated soil sites ARA-01, ARA-12, and ARA-23 (DOE-ID 2000a):

- Soil with contaminant concentrations in excess of the remediation goals will be removed using conventional earth-moving equipment (e.g., scrapers and backhoes). Remediation goals and maximum detected soil concentrations for the COCs are identified in Table 2-1.

- Surface soils inside the SL-1 burial ground (OU 5-05) exceeding the Cs-137 remedial action goal of 23 pCi/g will be remediated as part of ARA-23 under OU 5-12.

- Real-time analyses for radionuclides and near real-time analyses for metals will be used before and during excavation to delineate the extent of contamination for removal. Real-time analyses for radionuclides and soil sampling and laboratory analysis for radionuclides and metals will be used to confirm that remediation goals have been met.

- Contaminated soil will be characterized and sent to the INEEL CERCLA Disposal Facility (ICDF) or other location within the INEEL for permanent disposal.

- Institutional controls consisting of signs, access controls, and land-use restrictions will be established and maintained, depending on the results of confirmation sampling. However, institutional controls will not be required after remediation if all contaminated media are removed to basalt or if contaminant concentrations are comparable to local background values. Otherwise, institutional controls will be maintained until 2095 or discontinued sooner based on the results of a 5-year review.

- Five-year reviews will be conducted for remediated sites with institutional controls.

Table 2-1. Waste Area Group 5 contaminated soils remedial action goals.[a]

Site	Contaminant of Concern	Soil Concentration Remedial Action Goal	Maximum Soil Concentration
ARA-01	Arsenic	10 mg/kg	25.8 mg/kg
	Selenium	2.2 mg/kg	27.7 mg/kg
	Thallium	4.3 mg/kg	59.2 mg/kg
ARA-12	Ag-108m	0.75 pCi/g	67.2 pCi/g
	Copper	220 mg/kg	623 mg/kg
	Mercury	0.5 mg/kg	1.4 mg/kg
	Selenium	2.2 mg/kg	2.7 mg/kg
ARA-23	Cs-137	23 pCi/g	2,140 pCi/g

a. DOE-ID 2000b.

Removal of contaminated soil will be achieved using conventional excavation equipment. The relatively shallow depths of contaminated soils at WAG 5 sites will allow for excavation using front-end loaders, backhoes, and soil vacuum equipment.

Areas planned for excavation will be gridded, characterized, and excavated in discrete depth intervals. Excavation of the contaminated soils will be sequenced such that soil removal will begin in the farthest upwind area of each site and proceed in the direction of the prevailing wind. Meteorological data for the site will be used for planning the excavations. Real-time gamma surveys using large plastic scintillators, sodium-iodide detectors, and germanium spectrometers will be used for measurement of radiological contaminants. Near real-time x-ray fluorescence spectrometry and atomic absorption spectroscopy will be used for toxic metals. These field measurement systems will be used during excavation to delineate the extent of contamination for removal and to minimize the volume of uncontaminated soil removed. Excavation will only proceed to the depths at which contamination above the remediation goals is encountered as identified by the field screening methods. Sampling and analysis of soils underlying clean intervals will be used to confirm that all soil with contaminant concentrations above the remediation goals is removed.

Current radiological control practices will be implemented to minimize radiation exposure to the workers. Radiological controls may consist of limiting the amount of time an operator can work in the area, requiring personnel to wear personal protective clothing, and using distance and shielding to reduce radiation exposure. Air emissions will be controlled by the use of water sprays or soil fixatives to suppress dust during soil excavation and removal. Additionally, air monitoring may be conducted by the RadCon organization to ensure that dust suppression methods are effective in protecting personnel.

Soil hauling trucks will be positioned near the excavation so that loaders and backhoes can place the contaminated soil directly into the trucks. A tarp will be unrolled over each truck box and secured to prevent accidental release during transit. The contaminated soil will then be hauled to the ICDF.

Following remediation, excavations exceeding 0.3 m (1 ft) in depth will be backfilled with uncontaminated soil or sloped to promote drainage. Shallow excavations will be contoured using clean soil from the surrounding area to blend with the existing landscape. Sites will be vegetated in accordance with INEEL guidelines and the design specifications provided in the OU 5-12 Phase II remedial design/remedial action (RD/RA) work plan (DOE-ID 2003a).

Post-remediation requirements for institutional controls at each soil site, such as signs, access controls, and deed restrictions, will be determined after soil removal. Institutional controls will not be required if all soil down to basalt is removed and concentrations of residual contamination on the exposed basalt or remaining soil are comparable to background values. Otherwise, institutional controls will be maintained until 2095 or until restrictions are removed through a 5-year review.

3. SAMPLING DATA QUALITY OBJECTIVES

Data needs and data quality objectives (DQOs) for conducting the proposed sampling in support of the remedial action activities for the individual sites are defined in the following sections. Data needs have been determined through the evaluation of existing data and the projection of data requirements anticipated for the analysis of samples collected during the WAG 5 remedial action. The DQOs have been developed following the process outlined in *Guidance for the Data Quality Objectives Process* (EPA 1994).

3.1 ARA-01

3.1.1 Problem Statement

The first step in the DQO process is to state the problem to be addressed and to put it in programmatic context. There are three basic parts of the problem: soil excavation, waste designation, and interim closure. Soil excavation addresses the field input to guide excavation locations and minimize soil removal. Waste designation addresses the excavated soil, and will be addressed in a separate field sampling plan. Waste destined for disposal at the ICDF will be characterized in accordance with the *ICDF Complex Material Profile Guidance* (DOE-ID 2003b). Interim closure addresses soils remaining in place.

The problem statements associated with the DQO process are:

- Problem Statement 1—Given that the soil needs to be excavated and disposed of, collect near-real-time data to guide excavation locations and minimize soil disposal.
- Problem Statement 2—Interim closure: Given that the remaining soils are intended for interim closure, collect the characterization data required to meet the cleanup requirements specified in the ROD (DOE ID 2000a).

3.1.2 Decision Identification

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be resolved to address the problem statements identified in DQO Step 1 and the alternative actions that would result from the resolution of the PSQs. The PSQs and the associated alternative actions were combined into decision statements. The PSQs and resultant decision statements (DSs) are as follows:

- PSQ #1—How far and where should the excavation be carried out?
- DS #1—Determine the extent of initial excavation, and subsequent hot spot excavations.
- PSQ #2—Do soils remaining after remediation meet site remedial action goals?
- DS #2—Determine whether soils remaining after remediation meet site remedial action goals as specified in the ROD, and determine whether remediation is complete, as defined in Section 3.1.7.3.

3.1.3 Decision inputs

The purpose of DQO Step 3 is to identify the type of data needed to resolve each of the decision statements identified in DQO Step 2. This data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., practical quantitation limit [PQL] requirement, precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.1.3.1 Information Required to Resolve Decision Statements. It is necessary to determine the information (data) required to resolve each of the decision statements identified in Section 3.1.2 and identify whether these data already exist. For ARA-01, data for concentrations of arsenic, selenium, and thallium are needed. These data will consist of both field screening and laboratory measurements of contaminants of concern (COC). Data are required to estimate the depth distribution of contaminants to aid in the removal action, and data are required from the excavated soils to demonstrate compliance with the disposal facility waste acceptance criteria (WAC). Additionally, data are required of the remaining soils to demonstrate that the remedial action objectives have been achieved.

3.1.3.2 Basis for Setting the Action Level. The action level is the threshold value that provides the criterion for choosing between alternative actions. The basis for setting the action level for decision statements 1 and 2 is the potential for exceeding human health and/or ecological risk-based concentrations in the ARA-01 soils. The numerical values of the action levels are defined in DQO Step 5.

3.1.3.3 Computational and Survey/Analytical Methods. Table 3-1 identifies the decision statements where existing data either do not exist or are of insufficient quality to resolve the decision statements. Additionally, Table 3-1 presents computational and/or surveying/sampling methods that could be used to obtain the required data. Field screening samples will be collected for the metal contaminants to estimate the areal and depth distribution of the COCs exceeding the remedial action goals prior to and during the remedial action to support decision statement 1. However, a statistically-based number of samples will be collected for decision statement 2 where the 95% upper confidence limit (UCL) of the mean will be compared to the remedial action goals as defined in the ROD (DOE-ID 2000a).

Table 3-1. Information required to resolve the decision statements.

DS #	Required Data	Computational Methods	Survey/Analytical Methods Field screening for determination of metal concentrations in soils.
1	Chemical concentrations, extent of contamination, and WAC acceptability	Correlation of field screening to laboratory measurements	
2	Chemical concentrations in soil	Compare mean (95% UCL) to remedial action goals	Analytical laboratory determination of metal concentrations in soils.

3.1.3.4 Analytical Performance Requirements. Table 3-2 defines the analytical performance requirements for the data that need to be collected to resolve each of the decision statements. These performance requirements include the PQL, precision, and accuracy requirements for each of the COCs.

3.1.4 Study Boundaries

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each decision statement, and identify any practical constraints (hindrances or obstacles) that must be taken into consideration in the sampling design. Implementing this step ensures that the sampling design will result in the collection of data that accurately reflect the true condition of the site under investigation.

Table 3-2. Analytical performance requirements.

DS #	Target Analyte List	Survey/Analytical Methods	Preliminary Action Level	PQL	Precision Requirement	Accuracy Requirement
1	Arsenic	XRF	10 mg/kg	0.6 mg/kg	± 30%	70-130
	Selenium	XRF	2.2 mg/kg	0.6 mg/kg		
	Thallium	XRF	4.3 mg/kg	1.7 mg/kg		
2	Arsenic	SW-846	10 mg/kg	See QAPjP	± 30%	70-130
	Selenium	SW-846	2.2 mg/kg			
	Thallium	SW-846	4.3 mg/kg			

3.1.4.1 Population of Interest. Prior to defining the spatial and temporal boundaries of the site under investigation, it is first necessary to clearly define the populations of interest that apply for each decision statement. The populations of interest are as follows:

- DS #1—Contaminated and potentially contaminated soils prior to and during excavation
- DS #2—Remaining soils.

3.1.4.2 Geographic Boundaries. The geographic boundaries for decision statement 1 includes the lateral boundary depicted in Figure 2-3, approximately 7.6 cm (3 in.) deep across the area with additional volume coming from the removal of hot spots. The geographic boundary for decision statement 2 will be the footprint of the excavation.

3.1.4.3 Temporal Boundaries. The temporal boundary refers to both the time frame in which each decision statement applies and in which the data should be collected. The time frame for sample collection for decision statement 1 is limited to the duration of the soil excavation. Decision statement 2 sampling will take place after excavations are complete and field measurements show that contaminant levels are below the remedial action goals.

3.1.4.4 Practical Constraints. Practical constraints that may impact the data collection effort include physical barriers and potential background interference during field and laboratory measurements.

3.1.5 Decision Rule

The purpose of DQO step *5* is initially to define the statistical parameter of interest (i.e., mean or 95% UCL) that will be used for comparison against the action level. Table 3-3 summarizes the decision rules for the two decision statements provided in Section 3.1.2. These decision rules summarize the attributes the decision-maker needs to know about the sample population and how this knowledge will guide the selection of a course of action to solve the problem.

Table 3-3. Decision rules for the ARA-12 site.

DS#	DR#	Decision Rule
1	1	If any COC concentration exceeds the criteria stated in the ROD, then the soils will be removed; if all COC concentrations are below the remedial action goals, then the confirmation sampling will be carried out.
2	2	If the concentration representing the 95% UCL on the true population mean for each COC does not exceed the respective remedial action objective as stated in the ROD, then the site will be designated as remediated and closeout can proceed.

3.1.6 Decision Error Limits

Since analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). The primary objective of DQO Step 6 is to determine which decision statements, if any, require a statistically based sample design with tolerable limits on the probability of making a decision error, i.e., deciding that a site is clean when residual contamination in excess of the remedial action goal remains.

Taking into consideration the time frame in which each of the decision statements apply, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required, the soils affected by decision statement 2 have been retained for a statistical sampling design. Refer to Section 3.1.7 for details on the selected nonstatistical sampling designs for decision statement 1.

The two types of decision error that could occur are as follows: treating (managing and disposing of) clean site media as if it were contaminated and treating (managing and disposing of) contaminated site media as if it were clean. The decision error that has the more severe consequence is the latter, since the error could result in human health and/or ecological impacts. Given the two possible errors, null hypotheses were developed for each contaminant of concern stating the opposite of what the investigation hopes to demonstrate. The null hypotheses are stated as follows:

- The true mean concentration of arsenic exceeds the remedial action goal of 10 mg/kg as stated in the ROD
- The true mean concentration of selenium exceeds the remedial action goal of 2.2 mg/kg as stated in the ROD
- The true mean concentration of thallium exceeds the remedial action goal of 4.3 mg/kg as stated in the ROD.

The statistical parameter of interest is the contaminant concentration representing the 95% UCL of the true population mean. The gray region will be taken to be from 80% to 100% of the prescribed remedial action goals.

3.1.7 Design Optimization

The objective of DQO Step 7 is to present alternative data collection designs that meet the minimum data quality requirements as specified in DQO Steps 1 through 6. A selection process is then used to identify the most resource-effective, data collection design that satisfies all of the data quality requirements.

As stated in Section 3.1.6, the soils covered under decision statement 1 will be sampled following a nonstatistical approach. The remaining soils addressed in decision statement 2 will be sampled per a statistical design. The following subsections present the selected field screening, field measurement, and sampling methods for resolving each decision statement, along with a summary of the proposed implementation design.

3.1.7.1 Soil Removal Survey. Field screening will be used to identify hot spots and make decisions in the field as to whether or not further excavation is warranted. Final status of the site will be based on confirmation sample data.

The initial removal of soil at ARA-01 will involve excavating the top 7.6 cm (3 in.) over the entire pond surface. A minimum of 30 field-screening samples will then be collected from the newly exposed soil in the pond area based on a systematic grid to identify potential hot spots. Based on historical and characterization data, hot spots are anticipated near the pond inlet where contamination could extend to the soil/basalt interface; therefore, biased samples will also be taken adjacent to the pond inlet. All samples will be analyzed for arsenic, selenium, and thallium using an onsite, laboratory-grade, X-ray fluorescence (XRF) spectrometer. Method detection limits of the XRF spectrometer for arsenic, selenium, and thallium are, respectively, 0.6, 0.6, and 1.7 mg/kg. Based on the results of the field screening samples, further excavation will be performed in the identified hot spots until all contamination above the remedial action goals is removed, as demonstrated by field screening measurements, or until the basalt interface is exposed. Final status survey samples will then be collected from the area on a random-start grid to demonstrate that the ARA-01 pond area soils do not contain residual contamination at or above the remedial action goals.

3.1.7.2 Soil Disposal Survey. Process knowledge and historical sampling data for the COCs indicate that the excavated soils from the ARA-01 site do not exceed the ICDF WAC.

A nonstatistical survey will be performed on all of the excavated soils. Each waste container of soil will be screened for gamma activity using handheld sodium iodide detectors or similar instruments instruments and the required verification sampling will be performed in conjunction with the waste generator and the ICDF samplers under the direction of the ICDF waste specialist in accordance with the *ICDF Complex Waste Verification Sampling and Analysis Plan* (DOE-ID 2003c). Each waste container will be evaluated against pertinent transportation requirements and the ICDF WAC. As stated previously, it is not anticipated that the radiological levels of the ARA-01 soils will exceed the disposal facility WAC.

3.1.7.3 Statistical Sampling Design for Soils. After field screening samples indicate that COC concentrations are below the remedial action goals, the statistically based sampling design will be implemented. Initially, 30 data points from the field screening for each of the measured COCs will be randomly selected, and population variances (σ^2) of the COCs will be estimated. The largest variance estimate will then be used to calculate the number of confirmation samples needed. If the data are normally distributed and are not correlated, the null hypotheses will be tested by comparing the 95% UCL for each COC to the remedial action goals. Normality of the data will be tested graphically and through use of the Shapiro-Wilkes statistic. If data are not normally distributed, then an appropriate transform (i.e., log-normal transform) will be implemented. The 95% UCL is given by the following equation:

$UCL = \bar{x} + \frac{(t \cdot s)}{\sqrt{n}}$ where $\bar{x}$ is the population mean, t is obtained from statistical tables, s is the standard deviation, and n is the number of samples. It is important to note that the t-value is based on the degrees of freedom or the number of measurements/samples above the instrument detection limit, minus one. "Less-than-detectable" values will be taken as one-half the reported instrument detection limit when calculating the sample population mean. The following equation may be used to calculate the minimum number of confirmation samples (EPA 1994):

$$n_d = \sigma^2 \left\{ \frac{z_{1-\beta} + z_{1-\alpha}}{C_s - \mu_1} \right\}^2 + \frac{1}{2} (z_{1-\alpha})^2 \qquad (3\text{-}1)$$

where

n_d	=	number of samples
σ^2	=	sample variance
$z_{1-\beta}$	=	critical value for a false negative
$z_{1-\alpha}$	=	critical value for a false positive
C_s	=	remedial action goal
μ_1	=	mean concentration (lower bound of the gray region) where the site should be declared clean.

If the calculated number of samples is less than 10, then 10 samples will be collected. If the calculated number of samples is greater or equal to 10, then the calculated number of samples will be collected. The locations for the closeout samples will be randomly determined from the 30 field measurement locations. After collection and analysis, the 95% UCL of the COCs will be compared to the appropriate ROD cleanup goals for soils.

As noted above, the selected design was based on the error tolerances, as discussed in Section 3.1.6, and the needed comparability to other similar remediation sites. The parameters of the selected statistical design for soils that provide the most resource-effective data collection design are summarized as follows:

- Simple random design
- The statistical test of interest is a comparison of the 95% UCL to the remedial action goal
- The false-positive (α) error rate is 5%
- The false negative (β) error rate is 20%
- The lower bound of the gray region is 80% of the corresponding remedial action goal
- The upper bound of the gray region is the remedial action goal for all soils and COCs.

3.2 ARA-12

3.2.1 Problem Statement

The first step in the DQO process is to state the problem to be addressed and to put it in programmatic context. There are three basic parts of the problem: soil excavation, waste designation, and interim closure. Soil excavation addresses the field input to guide excavation locations and minimize soil removal. Waste designation addresses the excavated soil, and will be addressed in a separate field sampling plan. Waste destined for disposal at the ICDF will be characterized in accordance with the *ICDF Complex Material Profile Guidance* (DOE-ID 2003b). Interim closure addresses soils remaining in place.

The problem statements associated with the DQO process are:

- Problem Statement 1—Given that the soil needs to be excavated and disposed of, collect real-time data to guide excavation locations and minimize soil disposal.
- Problem Statement 2—Interim closure: Given that the remaining soils are intended for interim closure, collect the characterization data required to meet the cleanup requirements specified in the ROD (DOE ID 2000a).

3.2.2 Decision Identification

The purpose of DQO Step 2 is to define the PSQs that need to be resolved to address the problem statements identified in DQO Step 1 and the alternative actions that would result from the resolution of the PSQs. The PSQs and the associated alternative actions were combined into decision statements. The PSQs and resultant decision statements are as follows:

- PSQ #1—How far and where should the excavation be carried out?
- DS #1—Determine the extent of initial excavation, and subsequent hot spot excavations.
- PSQ #2—Do soils remaining after remediation meet site remedial action goals?
- DS #2—Determine whether soils remaining after remediation meet site remedial action goals as specified in the ROD, and determine whether remediation is complete, as defined in Section 3.2.7.3.

3.2.3 Decision Inputs

The purpose of DQO Step 3 is to identify the type of data needed to resolve each of the decision statements identified in DQO Step 2. This data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., PQL requirement, precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.2.3.1 Information Required to Resolve Decision Statements. It is necessary to determine the information (data) required to resolve each of the decision statements identified in Section 3.2.2 and identify whether these data already exist. For ARA-12, data for concentrations of Ag-108m, copper, mercury, and selenium are needed. These data will consist of both field and laboratory measurements of contaminants. Data are required to estimate the depth distribution of contaminants to aid in the removal action. Additionally, data are required of the remaining soils to demonstrate that the remedial action objectives have been achieved.

3.2.3.2 Basis for Setting the Action Level. The action level is the threshold value that provides the criterion for choosing between alternative actions. The basis for setting the action level for decision statements 1 and 2 is the potential for exceeding human health and/or ecological risk-based concentrations in the ARA-12 soils. The numerical values of the action levels are defined in DQO Step 5.

3.2.3.3 Computational and Survey/Analytical Methods. Table 3-4 identifies the decision statements where existing data either do not exist or are of insufficient quality to resolve the decision statements. Additionally, Table 3-4 presents computational and/or surveying/sampling methods that could be used to obtain the required data. Field measurements and field screening samples will be collected for radiological and chemical contaminants, respectively, to estimate the areal and depth distribution of the COCs exceeding the remedial action goals prior to and during the remedial action to support decision statement 1. This data may also be used to support decision statement 2; however, a statistically-based number of samples will be collected for decision statement 2 where the 95% UCL of the mean will be compared to the remedial action goals as defined in the ROD (DOE-ID 2000a).

Table 3-4. Information required to resolve the decision statements.

DS #	Required Data	Computational Methods	Survey/Analytical Methods
1	Radiochemical and chemical concentrations, extent of contamination, and WAC acceptability	Correlation of field measurements to laboratory measurements	Field and laboratory determination of radionuclide and chemical concentrations in soils.
2	Radiochemical and chemical concentrations in soil	Compare mean (95% UCL) to remedial action goals	Field measurements and analytical laboratory determination of radionuclide concentrations in soils and analytical laboratory determination of chemical concentrations in soils.

3.2.3.4 Analytical Performance Requirements. Table 3-5 defines the analytical performance requirements for the data that need to be collected to resolve each of the decision statements. These performance requirements include the PQL, precision, and accuracy requirements for each of the COCs.

Table 3-5. Analytical performance requirements.

DS #	Target Analyte List	Survey/Analytical Methods	Preliminary Action Level	PQL	Precision Requirement	Accuracy Requirement
1	Ag-108m	Gamma survey and Gamma Spec.	0.75 pCi/g	0.10 pCi/g	± 30%	70-130
	Copper	XRF	220 mg/kg	0.9 mg/kg		
	Mercury	AA Field Analyzer	0.5 mg/kg	0.04 mg/kg		
	Selenium	XRF	2.2 mg/kg	0.6 mg/kg		
2	Ag-108m	Gamma Spec.	0.75 pCi/g	See QAPjP	± 30%	70-130
	Copper	SW-846	220 mg/kg			
	Mercury	SW-846	0.5 mg/kg			
	Selenium	SW-846	2.2 mg/kg			

3.2.4 Study Boundaries

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each decision statement, and identify any practical constraints (hindrances or obstacles) that must be taken into consideration in the sampling design. Implementing this step ensures that the sampling design will result in the collection of data that accurately reflect the true condition of the site under investigation.

3.2.4.1 Population of Interest. Prior to defining the spatial and temporal boundaries of the site under investigation, it is first necessary to clearly define the populations of interest that apply for each decision statement. The populations of interest are as follows:

- DS #1—Contaminated and potentially contaminated soils prior to and during excavation
- DS #2—Remaining soils.

3.2.4.2 Geographic Boundaries. The geographic boundaries for decision statement 1 includes the lateral boundary depicted in Figure 2-6, approximately 7.6 cm (3 in.) deep across the area with additional volume coming from the removal of hot spots. The geographic boundary for decision statement 2 will be the footprint of the excavation.

3.2.4.2 Temporal Boundaries. The temporal boundary refers to both the time frame in which each decision statement applies and in which the data should be collected. The time frame for sample collection for decision statement 1 is limited to the duration of the soil excavation. Decision statement 2 sampling will take place after excavations are complete and field measurements show that contaminant levels are below the remedial action goals.

3.2.4.3 Practical Constraints. Practical constraints that may impact the data collection effort include physical barriers and potential background interference during field and laboratory measurements.

3.2.5 Decision Rule

The purpose of DQO step *5* is initially to define the statistical parameter of interest (i.e., mean or 95% UCL) that will be used for comparison against the action level. Table 3-6 summarizes the decision rules for the two decision statements provided in Section 3.2.2. These decision rules summarize the attributes the decision-maker needs to know about the sample population and how this knowledge will guide the selection of a course of action to solve the problem.

Table 3-6. Decision rules for the ARA-12 site.

DS#	DR#	Decision Rule
1	1	If any COC concentration exceeds the criteria stated in the ROD, then the soils will be removed; if all the COC concentrations are below the remedial action goals, then the confirmation sampling will be carried out.
2	2	If the concentration representing the 95% UCL on the true population mean for each COC does not exceed the respective remedial action objective as stated in the ROD, then the site will be designated as remediated, and closeout can proceed.

3.2.6 Decision Error Limits

Since analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). The primary objective of DQO Step 6 is to determine which decision statements, if any, require a statistically based sample design with tolerable limits on the probability of making a decision error, i.e., deciding that a site is clean when residual contamination in excess of the remedial action goal remains.

Taking into consideration the time frame in which each of the decision statements apply, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required, the soils affected by decision statement 2 have been retained for a statistical sampling design. Refer to Section 3.2.7 for details on the selected nonstatistical sampling design for decision statement 1.

The two types of decision error that could occur are as follows: treating (managing and disposing of) clean site media as if it was contaminated, and treating (managing and disposing of) contaminated site media as if it were clean. The decision error that has the more severe consequence is the latter, since the error could result in human health and/or ecological impacts. Given the two possible errors, null hypotheses were developed stating the opposite of what the investigation hopes to demonstrate. The null hypotheses are stated as follows:

- The true mean concentration of Ag-108m exceeds the remedial action goal of 0.75 pCi/g as stated in the ROD
- The true mean concentration of copper exceeds the remedial action goal of 220 mg/kg as stated in the ROD
- The true mean concentration of mercury exceeds the remedial action goal of 0.5 mg/kg as stated in the ROD
- The true mean concentration of selenium exceeds the remedial action goal of 2.2 mg/kg as stated in the ROD.

The statistical parameter of interest is the contaminant concentration representing the 95% UCL of the true population mean. The gray region will be taken to be from 80% to 100% of the prescribed remedial action goals.

3.2.7 Design Optimization

The objective of DQO Step 7 is to present alternative data collection designs that meet the minimum data quality requirements as specified in DQO Steps 1 through 6. A selection process is then used to identify the most resource-effective, data collection design that satisfies all of the data quality requirements.

As stated in Section 3.2.6, the soils covered under decision statement 1 will be sampled/surveyed following a nonstatistical approach. The remaining soils addressed in decision statement 2 will be sampled per a statistical design. The following subsections present the selected field screening, field measurement, and sampling methods for resolving each decision statement, along with a summary of the proposed implementation design.

3.2.7.1 Soil Removal Survey. Field screening will be used to identify hot spots and make decisions in the field as to whether or not further excavation is warranted. Final status of the site will be based on confirmation sample data. In situ gamma spectroscopy field measurements for Ag-108m will also be used to support the final status decision for ARA-12.

The initial removal of soil at ARA-12 will involve excavating the top 7.6 cm (3 in.) over the entire area defined in Figure 2-6. An additional 7.6 cm (3 in.) will be removed from the hot spot in the northeastern portion of the pond, an area roughly 6 × 20 m (20 × 65 ft). Field screening methods will then be used to identify any remaining hot spots. The excavated area will be surveyed with the ORTEC ISO-CART or similar system to identify Ag-108m hot spots that exceed the 0.75 pCi/g remedial action goal. A systematic grid will be generated, and all locations will be measured with the ISO-CART. The grid will be constructed with 12 m grid spacing (6 m radius). This will allow for overlap in the measurements, and provide 100% coverage of the area to ensure that no hot spots above the remedial action goal are missed. Additionally, a field screening composite sample will be collected at a minimum of 30 grid locations and analyzed for copper, mercury and selenium. Copper and selenium will be analyzed for using the laboratory XRF spectrometer, and mercury will be analyzed for using atomic absorption spectrometry. Based on the results of the radiological measurements and metals field screening, excavation will be performed in the identified hot spots until contamination above the remedial action goals is removed, as demonstrated by field screening measurements, or until the basalt interface is exposed. Confirmation sampling will then be conducted for final site closure, and will provide the final confirmation as described under statistical design below.

3.2.7.2 Soil Disposal Survey. Process knowledge and historical sampling data for the COCs indicate that the excavated soils from the ARA-12 site do not exceed the ICDF WAC.

A nonstatistical survey will be performed on all of the excavated soils. Each waste container of soil will be screened for gamma activity using handheld sodium iodide detectors or similar instruments instruments and the required verification sampling will be performed in conjunction with the waste generator and the ICDF samplers under the direction of the ICDF waste specialist in accordance with the *ICDF Complex Waste Verification Sampling and Analysis Plan* (DOE-ID 2003c). Each waste container will be evaluated against pertinent transportation requirements and the ICDF WAC. As stated previously, it is not anticipated that the contaminant levels of the ARA-12 soils will exceed the disposal facility WAC.

3.2.7.3 Statistical Sampling Design for Soils. After field measurements and screening samples indicate that COC concentrations are below the remedial action goals, the statistically based sampling design will be implemented. Initially, 30 data points from the field screening for each of the measured COCs will be randomly selected, and population variances (σ^2) of the COCs will be estimated. The largest variance estimate will then be used to calculate the number of confirmation samples needed. If the data are normally distributed and are not correlated, the null hypotheses will be tested by comparing the 95% UCL for each COC to the remedial action goals. Normality of the data will be tested graphically and through use of the Shapiro-Wilkes statistic. If data are not normally distributed, then an appropriate transform (i.e., log-normal transform) will be implemented. The 95% UCL is given by the following equation:

$UCL = \bar{x} + \frac{(t \cdot s)}{\sqrt{n}}$ where $\bar{\chi}$ is the population mean, t is obtained from statistical tables, s is the standard deviation, and n is the number of samples. It is important to note that the t-value is based on the degrees of freedom or the number of measurements/samples above the instrument detection limit, minus one. "Less-than-detectable" values will be taken as one-half the reported instrument detection limit when calculating the sample population mean. The following equation may be used to calculate the minimum number of confirmation samples (EPA 1994):

$$n_d = \sigma^2 \left\{ \frac{z_{1-\beta} + z_{1-\alpha}}{C_s - \mu_1} \right\}^2 + \frac{1}{2}(z_{1-\alpha})^2 \tag{3-2}$$

where

n_d	=	number of samples
σ^2	=	sample variance
$z_{1-\beta}$	=	critical value for a false negative
$z_{1-\alpha}$	=	critical value for a false positive
C_s	=	remedial action goal
μ_l	=	mean concentration (lower bound of the gray region) where the site should be declared clean.

If the calculated number of samples is less than 10, then 10 samples will be collected. If the calculated number of samples is greater or equal to 10, then the calculated number of samples will be collected. The locations for the closeout samples will be randomly determined from the 30 field measurement locations. After collection and analysis, the 95% UCL of the COCs will be compared to the appropriate ROD cleanup goals for soils.

As noted above, the selected design was based on the error tolerances, as discussed in Section 3.2.6, and the needed comparability to other similar remediation sites. The parameters of the selected statistical design for soils that provide the most resource-effective data collection design are summarized as follows:

- Simple random design
- The statistical test of interest is a comparison of the 95% UCL to the remedial action goal
- The false-positive (α) error rate is 5%
- The false negative (β) error rate is 20%
- The lower bound of the gray region is 80% of the corresponding remedial action goal
- The upper bound of the gray region is the remedial action goal for all soils and COCs.

Following the collection of the laboratory analytical data, a linear regression analysis of the field measurement data versus the laboratory gamma spectrometric data will be performed to determine how closely the sets of data are correlated. Linear regression analysis methodology is outlined in *Modeling Patterns in Data Using Linear and Related Models* (INEL 1997) and treated in many statistics books. Provided that the field screening systems have acceptable errors, the field screening systems will be used to determine whether site-specific remediation goals have been achieved.

3.3 ARA-23

3.3.1 Problem Statement

The first step in the DQO process is simply to state the problem to be addressed and to put it in programmatic context. There are three basic parts of the problem: soil excavation, waste designation, and interim closure. Soil excavation addresses the field input to guide excavation locations and minimize soil removal. Waste designation addresses the excavated soil, and will be addressed in a separate field sampling plan. Waste destined for disposal at the ICDF will be characterized in accordance with the *ICDF Complex Material Profile Guidance* (DOE-ID 2003b). Interim closure addresses soils remaining in place.

The problem statements associated with the DQO process are:

- Problem Statement 1—Given that the soil needs to be excavated and disposed of, collect real-time data to guide excavation locations and minimize soil disposal.

- Problem Statement 2—Interim closure: Given that the remaining soils are intended for interim closure, collect the characterization data required to meet the cleanup requirements specified in the ROD (DOE-ID 2000a).

3.3.2 Decision Identification

The purpose of DQO Step 2 is to define the PSQs that need to be resolved to address the problem statements identified in DQO Step 1 and the alternative actions that would result from the resolution of the PSQs. The PSQs and the associated alternative actions were combined into decision statements. The PSQs and resultant decision statements are as follows:

- PSQ #1—How far and where should the excavation be carried out?

- DS #1—Determine the extent of initial excavation, and subsequent hot spot excavations.

- PSQ #2—Do soils remaining after remediation meet site remedial action goals?

- DS #2—Determine whether soils remaining after remediation meet site remedial action goals as specified in the ROD, and determine whether remediation is complete, as defined in Section 3.3.7.3.

3.3.3 Decision Inputs

The purpose of DQO Step 3 is to identify the type of data needed to resolve each of the decision statements identified in DQO Step 2. This data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., PQL requirement, precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.3.3.1 Information Required to Resolve Decision Statements. It is necessary to determine the information (data) required to resolve each of the decision statements identified in Section 3.3.2 and identify whether these data already exist. For ARA-23 data for concentrations of Cs-137 are needed. These data will consist of both field and laboratory measurements of contaminants. Data are required to estimate the depth distribution of contaminants to aid in the removal action, and data are required from the excavated soils to demonstrate compliance with the disposal facility WAC. Additionally, data are required of the remaining soils to demonstrate that the remedial action objectives have been achieved.

3.3.3.2 Basis for Setting the Action Level. The action level is the threshold value that provides the criterion for choosing between alternative actions. The basis for setting the action level for decision statements 1 and 2 is the potential for exceeding human health and/or ecological risk-based concentrations in the ARA-23 soils. The numerical values of the action levels are defined in DQO Step 5.

3.3.3.3 Computational and Survey/Analytical Methods. Table 3-7 identifies the decision statements where existing data either do not exist or are of insufficient quality to resolve the decision statements. Additionally, Table 3-7 presents computational and/or surveying/sampling methods that could be used to obtain the required data. Field measurements will be collected for radiological contaminants to estimate the areal and depth distribution of the Cs- 137 exceeding the remedial action goal prior to and during the remedial action to support decision statement 1. This data may also be used to support decision statement 2. A statistically-based number of samples will be collected for decision statement 2 where the 95% UCL of the mean will be compared to the remedial action goals as defined in the ROD (DOE-ID 2000a).

Table 3-7. Information required to resolve the decision statements.

DS#	Required Data	Computational Methods	Survey/Analytical Methods
1	Radiochemical concentrations, extent of WAC acceptability	Correlation of field measurements to laboratory measurements	Field and laboratory determination of radionuclide concentrations in soils.
2	Radiochemical concentrations in soil	Compare mean (95% UCL) to remedial action goals	Field measurements and analytical laboratory determination of radionuclide concentrations in soils.

3.3.3.4 Analytical Performance Requirements. Table 3-8 defines the analytical performance requirements for the data that need to be collected to resolve each of the decision statements. These performance requirements include the PQL, precision, and accuracy requirements for each of the COCs.

Table 3-8. Analytical performance requirements.

DS #	Target Analyte List	Survey/Analytical Methods	Preliminary Action Level	PQL	Precision Requirement	Accuracy Requirement
1	Cs-137	Gamma survey and Gamma Spec.	23 pCi/g	1.0 pCi/g	±30%	70-130
2	Cs-137	Gamma survey and Gamma Spec.	23 pCi/g	See QAPjP	±30%	70-130

3.3.4 Study Boundaries

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each decision statement, and identify any practical constraints (hindrances or obstacles) that must be taken into consideration in the sampling design. Implementing this step ensures that the sampling design will result in the collection of data that accurately reflect the true condition of the site under investigation.

3.3.4.1 Population of Interest. Prior to defining the spatial and temporal boundaries of the site under investigation, it is first necessary to clearly define the populations of interest that apply for each decision statement. The populations of interest are as follows:

- DS #1—Contaminated and potentially contaminated soils prior to and during excavation

- DS #2—Remaining soils.

3.3.4.2 Geographic Boundaries. The geographic boundaries for decision statement 1 includes the lateral boundary depicted in Figure 2-5, ranging from 7.6–15 cm (3–6 in.) deep across the area with additional volume coming from the removal of hot spots. The geographic boundary for decision statement 2 will be the footprint of the excavation.

3.3.4.3 Temporal Boundaries. The temporal boundary refers to both the time frame in which each decision statement applies and in which the data should be collected. The time frame for sample collection for decision statement 1 is limited to the duration of the soil excavation. Decision statement 2 sampling will take place after excavations are complete and field measurements show that contaminant levels are below the remedial action goals.

3.3.4.4 Practical Constraints. Practical constraints that may impact the data collection effort include physical barriers and potential background interference during field and laboratory measurements.

3.3.5 Decision Rule

The purpose of DQO step *5* is initially to define the statistical parameter of interest (i.e., mean or 95% UCL) that will be used for comparison against the action level. Table 3-9 summarizes the decision rules for the two decision statements provided in Section 3.3.2. These decision rules summarize the attributes the decision-maker needs to know about the sample population and how this knowledge will guide the selection of a course of action to solve the problem.

Table 3-9. Decision rules for the ARA-23 site.

DS#	DR#	Decision Rule
1	1	If any COC concentration exceeds the criteria stated in the ROD, then the soils will be removed; if the all COC concentrations are below the remedial action goals, then the confirmation sampling will be carried out.
2	2	If the concentration representing the 95% UCL on the true population mean for each COC does not exceed the respective remedial action objective as stated in the ROD, then the site will be designated as remediated and closeout can proceed.

3.3.6 Decision Error Limits

Since analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). The primary objective of DQO Step 6 is to determine which decision statements, if any, require a statistically based sample design, with tolerable limits on the probability of making a decision error; i.e., deciding that a site is clean when residual contamination in excess of the remedial action goal remains.

Taking into consideration the time frame in which each of the decision statements apply, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required, the soils affected by decision statement 2 have been retained for a statistical sampling design. Refer to Section 3.3.7 for details on the selected nonstatistical sampling designs for decision statements 1 and 2.

The two types of decision error that could occur are as follows: treating (managing and disposing of) clean site media as if it was contaminated, and treating (managing and disposing of) contaminated site media as if it were clean. The decision error that has the more severe consequence is the latter, since the error could result in human health and/or ecological impacts. Given the two possible errors, a null hypothesis was developed stating the opposite of what the investigation hopes to demonstrate. The null hypothesis is stated as follows:

- The true mean concentration of Cs-137 exceeds the remedial action goal of 23 pCi/g as stated in the ROD.

The statistical parameter of interest is the contaminant concentration representing the 95% UCL of the true population mean. The gray region will be taken to be from 80% to 100% of the prescribed remedial action goals.

3.3.7 Design Optimization

The objective of DQO Step 7 is to present alternative data collection designs that meet the minimum data quality requirements as specified in DQO Steps 1 through 6. A selection process is then used to identify the most resource-effective, data collection design that satisfies all of the data quality requirements.

As stated in Section 3.2.6, the soils covered under decision statement 1 will be sampled/surveyed following a nonstatistical approach. The remaining soils addressed in decision statement 2 will be sampled per a statistical design. The following subsections present the selected field screening, field measurement, and sampling methods for resolving each decision statement, along with a summary of the proposed implementation design.

3.3.7.1 Soil Removal Survey. Field screening will be used to identify hot spots and make decisions in the field as to whether or not further excavation is warranted. Final status of the site will be based on confirmation sample data. In situ gamma spectroscopy field measurements for Cs-137 will also be used to support the final status decision for ARA-23.

The initial removal of soil at ARA-23 will involve excavating the top 7.6 cm (3 in.) over the entire area defined by the Cs-137 20 pCi/g isopleth in Figure 3-1. Exceptions to this include the SL-1 haul road corridor, the hot spots identified inside the SL-1 burial ground, and inside the fences of the ARA-I and ARA-II facilities. The initial excavation of the SL-1 haul road corridor, SL-1 burial ground hot spots, and the ARA-I and II facilities will remove the top 15 cm (6 in.) of contaminated soil. Further details on the soil excavation are discussed in the RD/RA Work Plan (DOE-ID 2003a). The excavated areas will then be surveyed with the GPRS to identify remaining hot spots. The hot spots will then be measured with the above ground high-purity germanium (HPGe) spectrometer to positively identify and quantify the remaining Cs-137 contamination. Additionally, estimates of the depth distribution of the remaining contamination will be made from the HPGe measurements. This will assist the field personnel in determining how deep to make the next cut of soil. The removal and field screening process at ARA-23 may require multiple iterations before the remedial action goal of 23 pCi/g is achieved. Use of field screening instrumentation will minimize the number of iterations and increase the efficiency of the removal by providing an estimate of the depth of residual hot spot contamination and directing the areal and vertical extent of hot spot removal. The number of soil samples collected will be minimized by using GPRS data to support the final status survey due to the vast expanse of the site and the comprehensive nature of the radiological field screening methods. Final status survey measurements and a limited number of confirmation samples will then be collected from the area on a random grid to demonstrate that ARA-23 area soils do not contain residual contamination at or above the remedial action goal.

3.3.7.2 Soil Disposal Survey. Process knowledge and historical sampling data for the COCs indicate that the excavated soils from the ARA-23 site do not exceed the ICDF WAC.

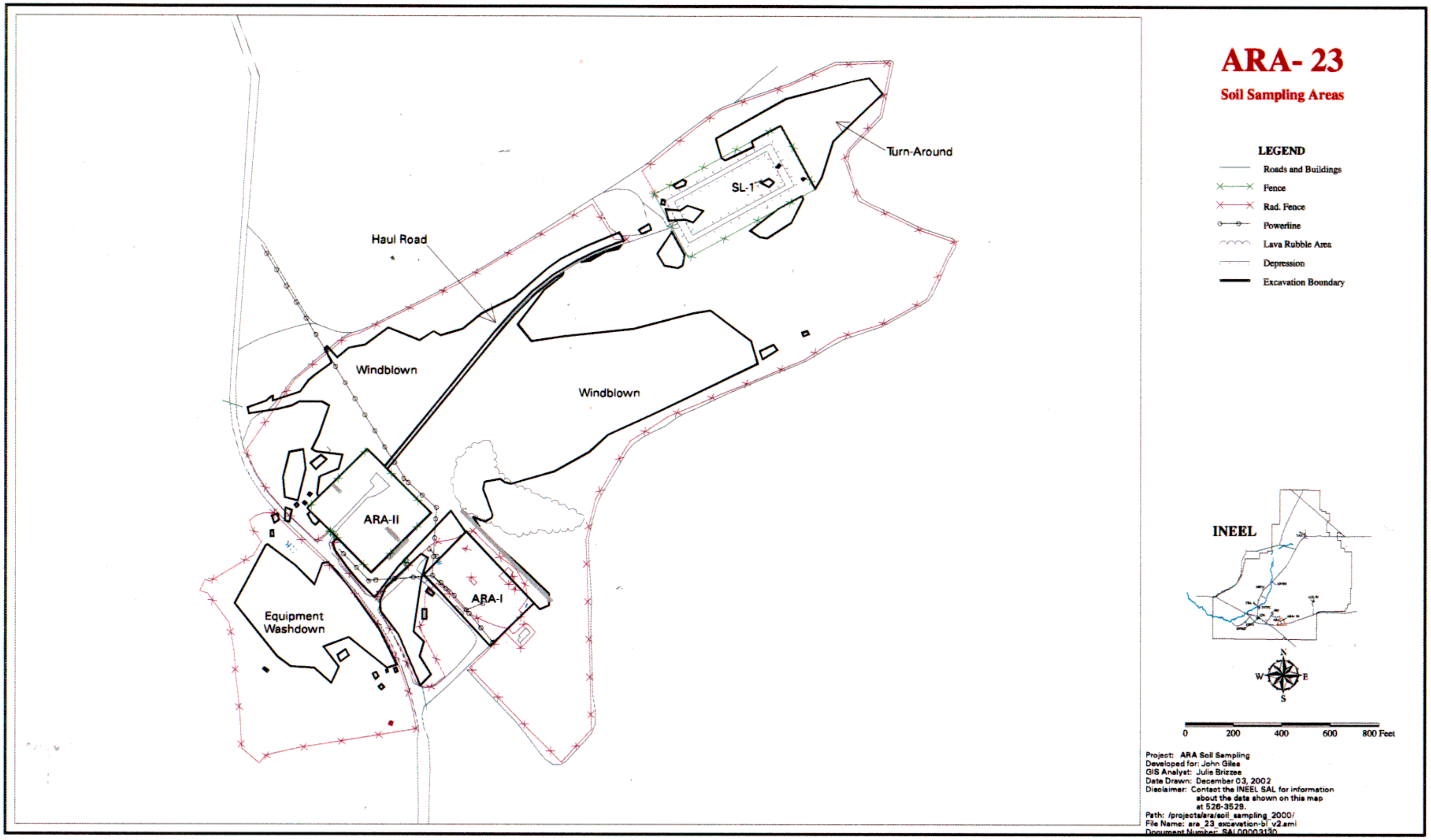

Figure 3-1. Cs-137 contamination at the ARA-23 site exceeding 20 pCi/g.

A nonstatistical survey will be performed on all of the excavated soils. Each waste container of soil will be screened for gamma activity using handheld sodium iodide detectors or similar instruments and the required verification sampling will be performed in conjunction with the waste generator and the ICDF samplers under the direction of the ICDF waste specialist in accordance with the *ICDF Complex Waste Verification Sampling and Analysis Plan* (DOE-ID 2003c). Each waste container will be evaluated against pertinent transportation requirements and the ICDF WAC. As stated previously, it is not anticipated that the radiological levels of the ARA-23 soils will exceed the disposal facility WAC.

3.3.7.3 Statistical Sampling Design for Soils. After field measurements indicate that Cs-137 concentrations are below the remedial action goals, the statistically based sampling design will be implemented. The ARA-23 area will be divided into 5 separate areas for consideration under the statistical sampling: 1) ARA-I facility, 2) ARA-II facility, 3) haul road and turn around area, 4) equipment washdown area, and 5) windblown area. The area within the boundaries of the SL-1 burial ground will be included with the haul road and turn around areas. Initially, 30 data points from the field measurements will be randomly selected from each area, and population variance (&) of the Cs-137 concentrations will be estimated. The variance estimate will then be used to calculate the number of confirmation samples needed for each area. If the data are normally distributed and are not correlated, the null hypothesis will be tested by comparing the 95% UCL to the remedial action goal. Normality of the data will be tested graphically and through use of the Shapiro-Wilkes statistic. If data are not normally distributed, then an appropriate transform (i.e., log-normal transform) will be implemented. The 95% UCL is given by the following equation: $UCL = \bar{x} + \frac{(t \cdot s)}{\sqrt{n}}$ where $\bar{x}$ is the population mean, *t* is obtained from statistical tables, s is the standard deviation, and n is the number of samples. It is important to note that the *t*-value is based on the degrees of freedom or the number of measurements/samples above the instrument detection limit, minus one. "Less-than-detectable" values will be taken as one-half the reported instrument detection limit when calculating the sample population mean. The following equation may be used to calculate the minimum number of confirmation samples (EPA 1994):

$$n_d = \sigma^2 \left\{ \frac{z_{1-\beta} + z_{1-\alpha}}{C_s - \mu_1} \right\}^2 + \frac{1}{2}(z_{1-\alpha})^2 \qquad (3\text{-}3)$$

where

n_d	=	number of samples
σ^2	=	sample variance
$z_{1-\beta}$	=	critical value for a false negative
$z_{1-\alpha}$	=	critical value for a false positive
C_s	=	remedial action goal
μ_1	=	mean concentration (lower bound of the gray region) where the site should be declared clean.

If the calculated number of samples is less than 10, then 10 samples will be collected in each of the five areas. If the calculated number of samples is greater or equal to 10, then the calculated number of samples may be collected if the accuracy or precision of the field measurement systems exceeds the PQLs listed in Table 3-8. The locations for the confirmation samples will be randomly determined from the field measurement locations. After collection and analysis, the 95% UCL of the COCs will be compared to the appropriate ROD cleanup goals for soils.

As noted above, the selected design was based on the error tolerances, as discussed in Section 3.3.6, and the needed comparability to other similar remediation sites. The parameters of the selected statistical design for soils that provide the most resource-effective data collection design are summarized as follows:

- Simple random design
- The statistical test of interest is a comparison of the 95% UCL to the remedial action goal
- The false-positive (α) error rate is 5%
- The false negative (β) error rate is 20%
- The lower bound of the gray region is 80% of the corresponding remedial action goal
- The upper bound of the gray region is the remedial action goal for all soils and COCs.

Following the collection of the laboratory analytical data, a linear regression analysis of the field measurement data versus the laboratory gamma spectrometric data will be performed to determine how closely the sets of data are correlated. Linear regression analysis methodology is outlined in *Modeling Patterns in Data Linear and Related Models* (INEL 1997) and treated in many statistics books. Provided that the field screening systems have acceptable errors, the field screening systems will be used to determine whether site-specific remediation goals have been achieved.

3.4 Quality Assurance Objectives for Measurement

The quality assurance (QA) objectives for measurement will meet or surpass the minimum requirements for data quality indicators established in the QAPjP (DOE-ID 2002a). This reference provides minimum requirements for the following measurement quality indicators: precision, accuracy, representativeness, detection limits, completeness, and comparability. Precision, accuracy, and completeness will be calculated as per the QAPjP (DOE-ID 2002a).

3.4.1 Precision

Precision is a measure of the reproducibility of measurements under a given set of conditions. In the field, precision is affected by sample collection procedures and by the natural heterogeneity encountered in the environment. Overall precision (field and laboratory) can be evaluated by the use of duplicate samples collected in the field. Greater precision is typically required for analytes with very low action levels that are close to background concentrations.

Laboratory precision will be based upon the use of laboratory-generated duplicate samples or matrix spike/matrix spike duplicate samples. Evaluation of laboratory precision will be performed during the method data validation process.

Field precision will be based upon the analysis of collected field duplicate or split samples. For samples collected for laboratory analyses, a field duplicate will be collected at a minimum frequency of 1 in 20 environmental samples.

Precision of field screening samples for metals, and field measurements for radionuclides will be based on the collection of duplicate samples and duplicate measurements. Duplicate samples and measurements will be collected at a frequency of 1 in 20 field screening samples and 1 in 20 field measurements.

3.4.2 Accuracy

Accuracy is a measure of bias in a measurement system. Laboratory accuracy is demonstrated using laboratory control samples, blind quality control (QC) samples, and matrix spikes. Evaluation of laboratory accuracy will be performed during the method data validation process. Sample handling, field contamination, and the sample matrix in the field affect overall accuracy. False positive or high-biased sample results will be assessed by evaluating results from field blanks, trip blanks, and equipment rinsates.

Field accuracy will only be determined for samples collected for laboratory analysis. The accuracy of field instrumentation will be ensured through the use of appropriate calibration procedures and standards.

3.4.3 Representativeness

Representativeness is a qualitative parameter that expresses the degree to which the sampling and analysis data accurately and precisely represent the characteristic of a population parameter being measured at a given sampling point or for a process or environmental condition. Representativeness will be evaluated by determining whether measurements are made and physical samples are collected in such a manner that the resulting data appropriately measure the media and phenomenon measured or studied. The comparison of all field and laboratory analytical data sets obtained throughout this remedial action will be used to ensure representativeness.

3.4.4 Detection Limits

Detection limits for laboratory analyses will meet or exceed the risk-based or decision-based concentrations for the COCs. Detection limits will be as specified in the Sample Analytical Management (SAM) laboratory Master Task Agreement statements of work, task order statements of work, and as described in the QAPjP (DOE-ID 2002a).

Detection limits for field instrumentation will also meet or exceed the remedial action goals for the COCs, and are discussed in Section 6.1.1.

3.4.5 Completeness

Completeness is a measure of the quantity of usable data collected during the field sampling activities. The QAPjP (DOE-ID 2002a) requires that an overall completeness goal of 90% be achieved for noncritical samples. If critical parameters or samples are identified, a 100% completeness goal is specified. Critical data points are those sample locations or parameters for which valid data must be obtained in order for the sampling event to be considered complete. For this project, all field screening data will be considered noncritical with a completeness goal of 90%. The laboratory data collected for confirmation samples will be considered critical with a completeness goal of 100%.

3.4.6 Comparability

Comparability is a qualitative characteristic that refers to the confidence with which one data set can be compared to another. At a minimum, comparable data must be obtained using unbiased sampling designs. If sampling designs are not unbiased, the reasons for selecting another design should be well documented. Data comparability will be assessed through the comparison of all data sets collected during this study for the following parameters:

- Data sets will contain the same variables of interest
- Units will be expressed in common metrics
- Similar analytical procedures and QA will be used to collect data
- Time of measurements of variables will be similar
- Measuring devices will have similar detection limits
- Samples within data sets will be selected in a similar manner
- Number of observations will be of the same order of magnitude.

3.5 Data Validation

Method data validation is the process whereby analytical data are reviewed against set criteria to ensure that the results conform to the requirements of the analytical method and any other specified requirements.

Ten percent of the laboratory-generated analytical data will be validated to Level A per INEEL GDE-7003, "Levels of Analytical Method Data Validation." Level A validation is the most stringent validation level requiring review of all laboratory QA/QC data, as well as raw data generated as a result of the analytical process. All other laboratory data will be subjected to a cursory review. If problems with the data are encountered during Level A validation (data are being rejected), all analytical data will be validated to Level A.

Field-generated data will not be validated. Quality of the field-generated data will be ensured through adherence to established operating procedures and use of equipment calibration as appropriate.